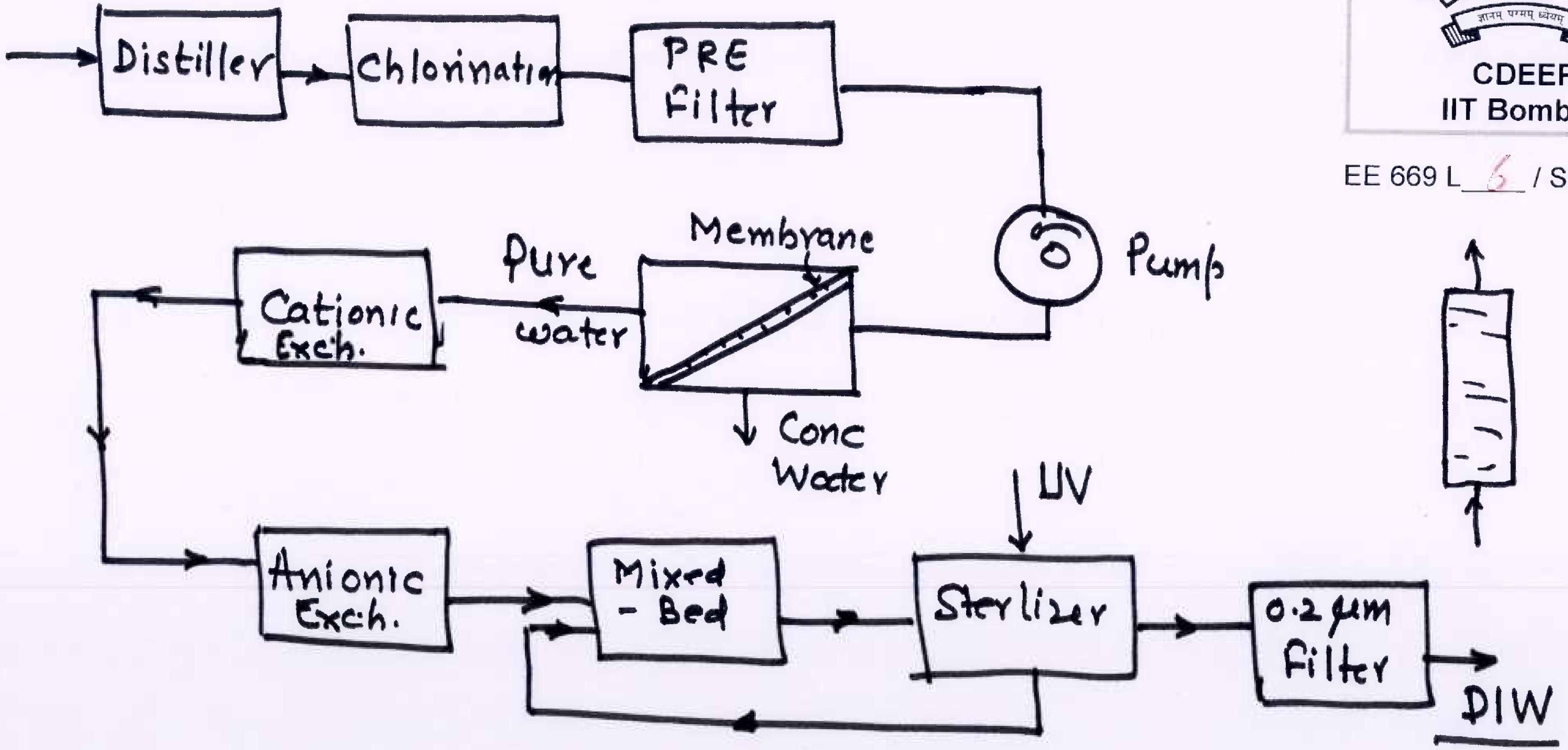
RO System



CDEEP
IIT Bombay

EE 669 L 6 / Slide 01

— Accessories —

Tubing : Stainless Steel and Teflon

Equipment : 1. Quartzware 2. Teflonware
3. Polypropylene 4. SS & Tweezers

Chemicals : 1. Organic 2 Inorganic (Acids & Base)

1. Organic: TCE, TCA, Acetone, Benzene, Photoresists

2. Inorganic: HCl, HF, H_2SO_4, HNO_3
NH_4OH, H_2O_2, H_3PO_4, NH_4F

All chemicals should be MOS Electronic Grade

Gases :— O_2, O_3, N_2, H_2, HCl, TCA, N_2O, NH_3, Argon
Phosphene PH_3, AsH_3, B_2H_6, Silane (SiH_4), $SiCl_4$, $SiHCl_3$
CH_3Cl, $C_2H_2Cl_2$, F, CF_4, S_2F_6

— DIFFUSION —

Impurity Incorporation in Semiconductors

All Semiconductor Devices use multiple impurity regions. Eg. Diode has two regions p type and n-type. We start with say n-type region doped with n-type impurities say Phosphorous (or Arsenic). This can be starting wafer from Crystal Growth. To make a diode, we must introduce P-type impurities (Boron) in this Substrate. Introduction of Impurities should be controllable both in total Impurities needed and depth to which these impurities should penetrate.

Impurities can be incorporated in Silicon Crystal by following processes

1. During CZ crystal growth, we add fixed amount of desired impurities in the Melt.
2. [redacted] During FZ crystal Growth, Crystal can be doped by Zone-Leveling technique.
3. In Epitaxial growth, impurities gets uniformly distributed in growth process
4. Solid State Diffusion is major source of impurity incorporation.
5 Ion Implantation is the most popular technique of Impurity incorporation.

Epitaxial Growth

EPI-layer n or p Si

Substrate Si / or any

However more important issue is to know how these impurities transport in crystalline material. This process of transport is known as 'Diffusion'. Any time-temp. cycle sees impurities-diffusion in space of the Crystal.

Definition: Diffusion is the Process by which atoms move in Crystal Lattice. The motion of an Impurity atom in a lattice, takes place in series of Random Jump (3D process). The net jump position is the Statistical Average.

Hence for controlled and specific impurity motion, one must study "Physics of Diffusion". Please note that even Silicon atoms diffuse in Silicon (By diffusion) and the process is called "Self Diffusion"

How do Impurities influence electrical behavior of Semiconductor (devices/Circuits)??

Electrical Properties are influenced by :

(a) Type of Majority Carriers

(b) Carrier Concentration

(c) Carrier Conc. Gradients

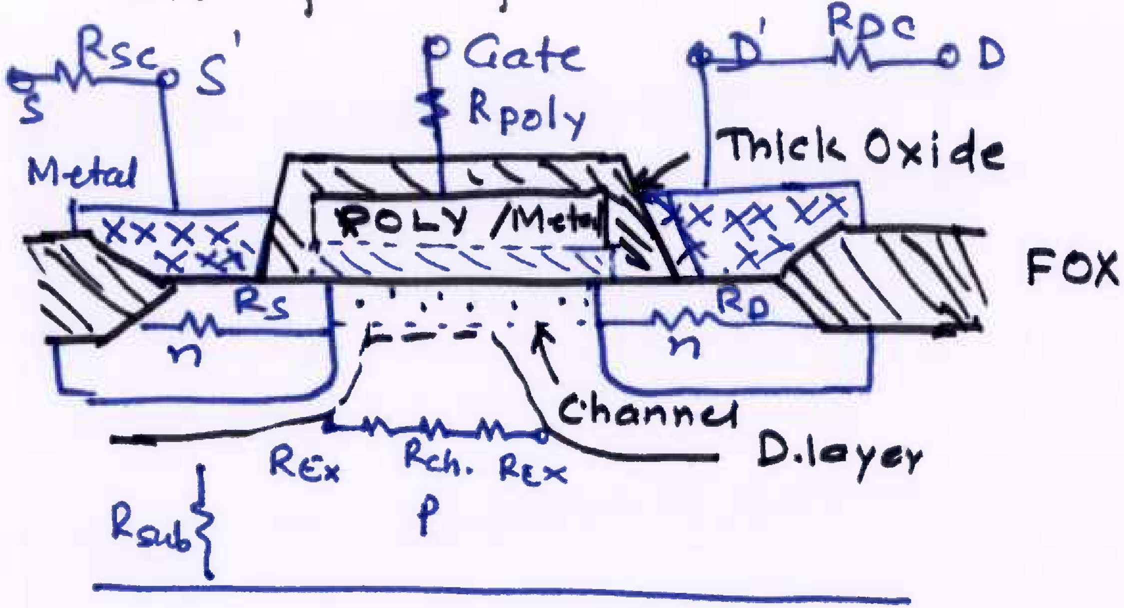
(d) Carrier Life time

(e) Internal Electrical Field

Impurities used in Semiconductor Devices, show energy level/levels in Semiconductor Bandgap.

N-type Impurities show energy level close to (but below) the conduction band edge; While p-type show energy level close to valance-band edge.

Example of MOS Transistor



(i) Source & Drain regions are created in Substrate with opposite doping.

(ii) Doped Poly gives metal like resistivity for Gate.

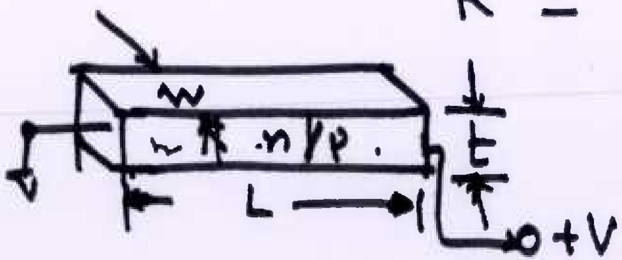
(iii) Parasitics like R_S, R_D, R_{ext}, R_{SC}, R_{DC} impact the I_{Dsat}, the Drive current

(iv) Short-channel effects are defined the dopings around S & D in the MOS device.

(v) Leakage currents are function of S & D and substrate doping.

Resistance of Semiconductor bar with known doping

$$R = \frac{\rho L}{A} = \frac{\rho L}{W \cdot t} = \left(\frac{\rho}{t}\right)(L/W)$$

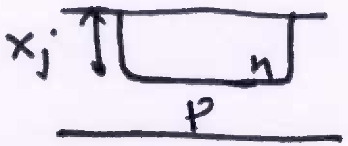


$\left(\frac{\rho}{t}\right)$ is called Sheet Resistivity or Sheet Resistance R_S

$\therefore$ $R = R_S (L/W)$; (L/W) is seen as ASPECT RATIO

σ = Conductivity $= \frac{1}{\rho}$

$= (q \mu_n n + q \mu_p p)$



If we apply a voltage V across the Bar,

the $\mathcal{E} = \frac{V}{L}$ = Electric field along direction of current flow

The current density $J = \sigma \mathcal{E}$ (This is Drift Current)

(vi) In the Doped region, the sheet resistance is evaluated as

$$R_s = \frac{\rho}{x_j}$$ where x_j is Junction Depth.

and $\rho = \frac{1}{(q \mu_n n + q \mu_p p)}$ is Specific Resistivity